The System of Distance Learning in the Scientific and Engineering Staff Training

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Abstract: The proposed computer system implements a scheme of joint - classroom and distance learning, scientific and exploratory research in order to motivate and stimulate students' independent work in acquiring professional competencies. The developed system reflects both the traditional structure of education in universities using groups of students, specialties and curricula, as well as modern trends in the transition to distance learning, i.e. the opportunity to study at any time and in any place, according to individual plans and schedules. The presented development can be used by students to acquire and develop competencies in the field of improving and managing technological processes for the production of metal products, including the design of machines and metal structures for additive technologies. This is ensured both by the created (and permanently updated) database of mechanical and technological characteristics of steels and alloys used in the production of materials for special purposes, including for the nuclear power industry and the chemical industry, product quality and environmental safety, and by programs developed on based on author's methods and implemented in the system of distance education, in particular, for calculating the modes of shaping and energy-power parameters in the formation of metal products.

Keywords: Distance learning, Engineering training

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Introduction

The educational sphere differs from all others in that it is always relevant to improve the technology of curriculum management. Therefore, innovative work in this type of activity never stops, and at present, with the development of computer technology, it has also intensified. In addition, the amount of knowledge that a student needs to acquire in order to meet professional competencies is also increasing. Therefore, scientific and technological research is carried out in the education system in the methodology of mastering knowledge and evaluating its effectiveness.

The problem of distance learning using the Internet (E-learning) has recently received much attention in the world (Sadoy & Mashkova, 2022; Osadchy, et al., 2019). This is due to the advantages that open up when using this form of training, first of all, there is no need to move students for a long time to the location of the university. This makes it possible to obtain the necessary knowledge for those who, for example, cannot leave work or leave for some other reason. In addition, teachers from leading universities can teach students around the world, which has been actively practiced in recent years by leading universities and educational centers.

The SCORM distance interactive learning standard developed and currently in force defines the general requirements for software (Vorontsov, 2023). This direction is recognized as progressive among educational projects (Semenova, 2013; Novikov, 2019). It must be developed so that residents of small towns and rural areas, as well as in large cities where the required specialty is not available at the local university, can receive vocational training that meets educational standards.

Currently available systems of distance learning are in fact limited to either only the provision of educational materials, or, in extreme cases, provide the opportunity for testing. At the same time, "intelligent" learning systems have not yet been sufficiently developed. Such systems should provide automatic management of the learning process, starting with planning in time, tracking and eliminating gaps in knowledge, and then changing the learning trajectory depending on the individual training and abilities of each student.

Independent work of students in the study of any disciplines, including fundamental and technical, as well as research work, is a very important component of the educational process, since it affects the level of knowledge and skills acquired by students. The development of computers and the Internet can be of great help in

developing the competencies of future engineering graduates and beyond. Today, students spend a lot of personal time online, and this should be used for educational purposes. Therefore, improving the organization of this area of the educational process is the goal of this work.

In the process of acquiring the competencies of engineering specialties, for example, a metallurgical profile, a student is faced with a wide variety of steels and alloys, their heat treatment modes, service characteristics, as well as methods of obtaining and testing. In the process of carrying out his research work, it becomes relevant for him to have a database of such materials. For this purpose, the program of the database of mechanical and technological characteristics of steels and alloys was adapted into the developed software package.

Thanks to the development of network information technologies, a program is built into the proposed computer system, which, in research work, including student work, along with the use of structured data, makes it possible to implement mathematical models of phenomena and technological processes. In this direction, the developed program, in particular, carries out computer design of technological equipment in the manufacture of roll-formed profiles, the production of which has recently been growing significantly.

Method

A computer system (software package) has been created, which is an educational and scientific platform that implements a scheme of mixed (classroom and distance) learning, scientific and exploratory research in order to motivate and stimulate students' independent work in acquiring professional competencies. The main purpose of the system: providing educational materials; automatic generation and issuance of tasks; organization and control of independent work of students; knowledge control; determining the rating of students; obtaining operational information about the state of the educational process, its analysis and improvement; use of active teaching methods; introduction of various forms of communication into the educational process; transparency of teachers' work; issuance of documentation and reports; performing calculations and scientific research.

Distance learning process

The paper proposes and puts into practice an approach, the purpose of which is to ensure the systematic work of students - this is a “rigid” scheme that regulates the conditions for studying each discipline, learning along the so-called “individual trajectory”. The essence of this method lies in the fact that the student consistently receives portions of educational material and tests to test the assimilation of knowledge. In case of unsatisfactory passing of the test, the system returns it to the re-study of the relevant sections of the course (discipline). At the same time, the deadlines and the actual time spent are automatically controlled. As a result, information is accumulated on the degree of assimilation of the material (grades and points). Penalty points for late completion of work and the use of additional attempts stimulate the regularity of work and careful study of the material. The

teacher at any time can see the progress of each student along his trajectory and receive information about the assimilation of the material on each topic, which makes it possible to eliminate gaps in knowledge.

Independent research work

Database of mechanical and technological characteristics. To store information about the chemical composition of metallic materials, their properties and other characteristics, a database of the Microsoft SQL-server type was created in the Microsoft Visual Studio environment to work under the Microsoft Windows operating system and the Microsoft SQL Server DBMS. In addition to characteristic data, each database table contains information for organizing links between tables, as well as about the creation of a record and the changes made (author and date) in order to increase its reliability.

The program allows you to enter new information, edit existing information and make queries to find the right data. Search results are displayed on the screen and in a file in the form of text, tables and graphs.

Calculation of the stress-strain state. To calculate the shaping mode, energy-power parameters during the formation of a pipe billet in accordance with the developed methods, a computer program was created in the Visual Studio environment in the C# language. The program is a Web-application for the Internet with a modern interface, embedded in a distance learning system. The program algorithm is an implementation of a mathematical model of the process of profiling a strip with horizontal and vertical rolls, which makes it possible to calculate the geometric and energy-power parameters of the process (Osadchiy et al., 2007; Osadchy et al., 2018; Osadchy, Savina, & Savin, 2018). The computer program “Gnut” was used as a basis for calculating roll gauges in the production of bent symmetrical and asymmetrical profiles of almost any real configuration with the issuance of a complete set of drawings. The program has no analogues so far.

Results

The results of using the software product in the educational process

The presented data concern mainly only students of one institute. although these approaches are also applicable when reading fundamental and technical disciplines for students of other institutes/universities.

After authorization on the site (figure 1), the student chooses the academic discipline of the current semester and receives a complete set of educational and methodological materials, as well as additional materials - scanned sources, which eliminates the need to waste time searching for the literature agreed with the teacher. In addition, the system has a library of scanned textbooks and manuals (over 5,000 titles) available for reading to students and teachers, as well as a catalog of books and magazines in the reading rooms.

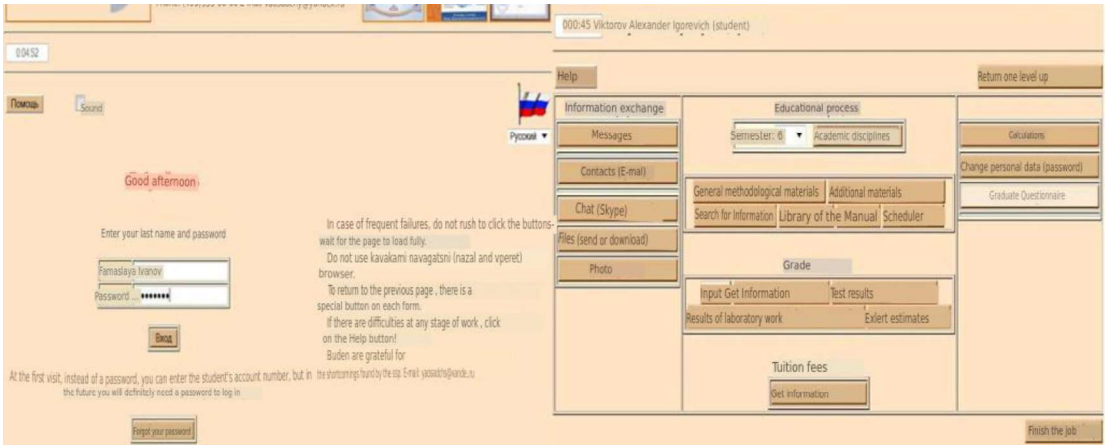


Figure 1. Authorization pages (login) and the main form of student work

A “rigid” scheme has been developed and implemented that regulates the conditions for studying each discipline - this is training along the so-called “trajectory” (figure 2). The student consistently receives portions of educational material and tests to test the assimilation of knowledge. In case of unsatisfactory passing of the test, the system returns it to the re-study of the relevant sections of the course. In order to exclude formal turning, the minimum time for studying a fragment (page) is set.

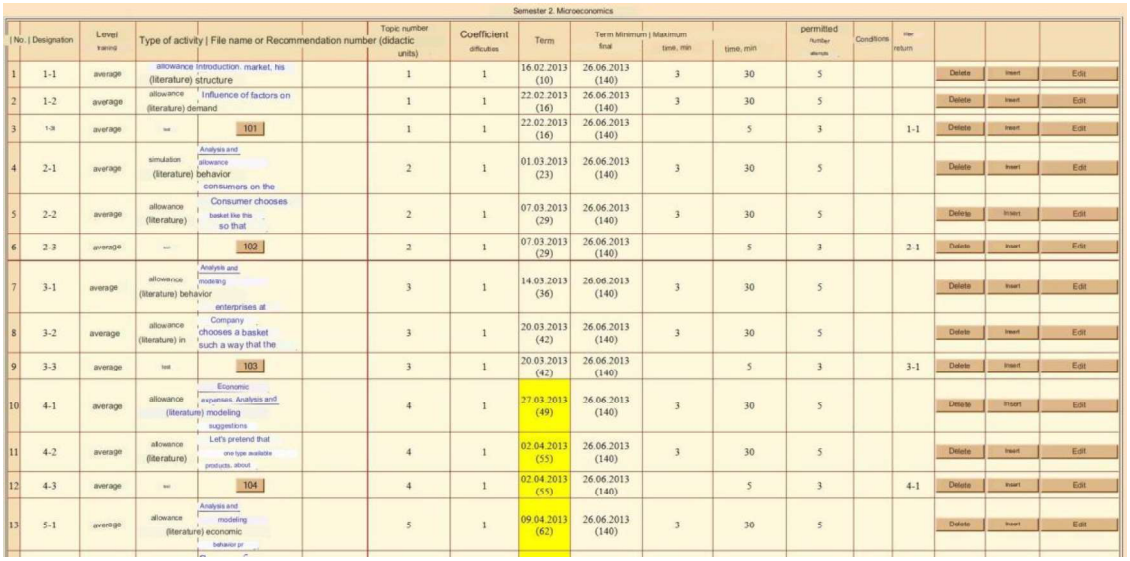


Figure 2. The trajectory of the study of the academic discipline

The teacher has the ability to adjust the trajectory (for example, the dates of work). Students have access to individual steps of the trajectory about a week before the deadline. The deadlines and time spent has been controlled. As a result, information is accumulated on the degree of assimilation of the material (grades and

points). Penalty points for late completion of work and the use of additional attempts stimulate the regularity of work and careful study of the material.

The teacher in a visual form in a graphical form at any time can see the progress of each student of the group along the trajectory. The teacher also can get information about the assimilation of the material on each topic, as well as questions that the student could not give the correct answer for the interview, which actually allows you to eliminate gaps in knowledge. The teacher enters into the system: class attendance and grades given in practical and seminar classes, for tests, homework, essays, term papers, grades in tests and exams (figure 3).

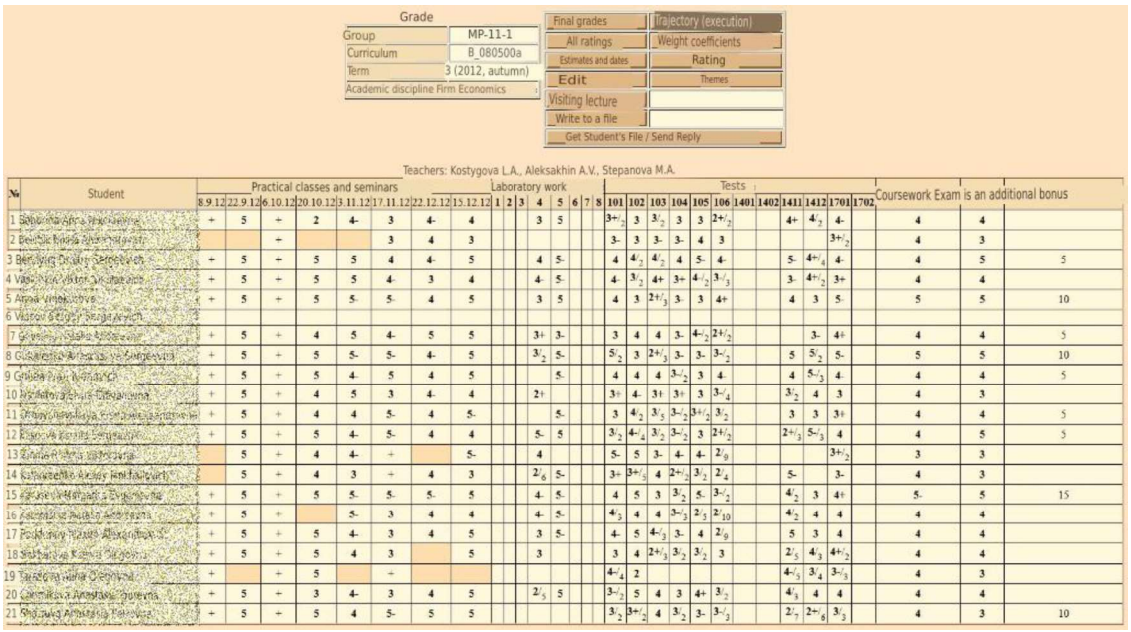


Figure 3. Teacher's Journal

Testing is provided to ensure the objectivity of the results. Along with the usual types of test questions, complex tasks with an arbitrary number of numeric and text parameters to be checked, with a given algorithm, are widely used. The program determines the difficulty of the question, highlights questionable and too easy questions. In addition, it also provides for confirmatory (in the classroom, with a teacher) testing and independent monthly mandatory testing on issues based on existing educational standards. The dynamics of testing is shown in Figure 4. Note that the peak of testing can be shifted in time depending on the total academic load (load) of the student in the current semester.

Given that people remember quite a bit of what they see, more of what they see and hear, a lot of what they see, hear and do, much attention is paid to the creation of a laboratory workshop. Students can perform laboratory work both in the computer classes of the educational institution and from home computers. At the same time, in all laboratory work, a tolerance in the form of a test is provided. The description of the laboratory work, as well

as other educational materials, may contain video fragments. In the educational process in fundamental and technical disciplines, films are used that are sometimes shown in the classroom, but more often students are given the task to watch them at home in the system for subsequent discussion in class.

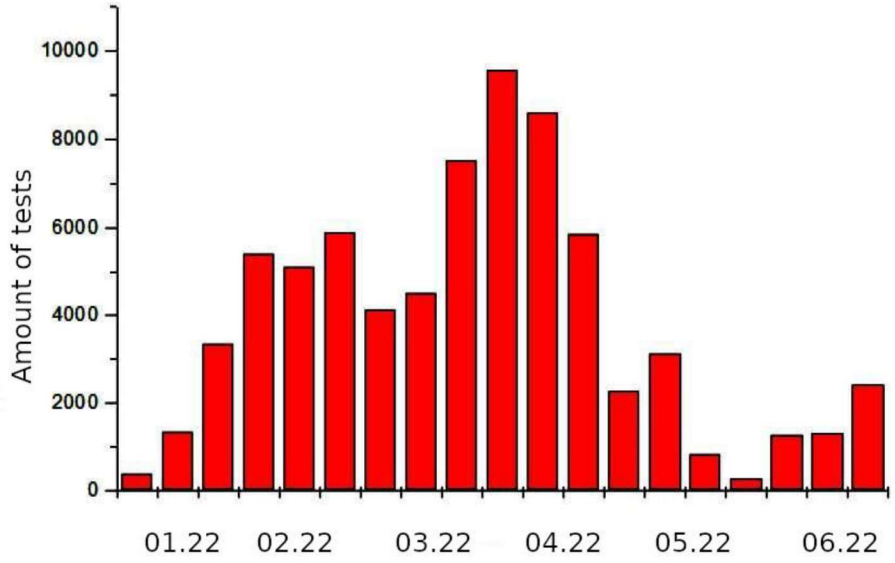


Figure 4. Test dynamics

The student sends completed tasks to the teacher from the page of the academic discipline, and the teacher sees them and receives them on the page of the journal. Teachers have the ability to control the dynamics of each student's work. The system implements automatic registration of attendance at lectures in classrooms where computers are installed.

The results of using the software package in research work

The figure 5 shows the page for selecting a subroutine to perform certain calculations.

Figure 5. Scientific research and calculations

The results of working with the database. Given the needs of production, the database includes, in fact, all types of metallic materials. All branded variety of materials is subdivided according to a number of classification features - type (black and non-ferrous), alloying degree, purpose. The chemical composition of the material indicates the content of 66 elements - in fact, all the elements used in pure form, in the form of alloys or as alloying additives. As characteristic features of each group of materials, the limiting content of elements in them is given. Tables have also been created to store information about the technological characteristics, physical and mechanical properties of materials, including taking into account the features of their production and heat treatment modes. Taking into account the classification of metallic materials, they are divided into a number of groups, information about which is stored in the MateGr table. The chemical compositions of various grades of metal materials in Russia and other countries, some of their characteristics are stored in the Maters database.

The main form of the program is presented in the form of a menu - buttons for switching to one of the main functions (Figure 6). In addition, the program contains a section that allows you to quickly perform various conversions of mass, length, time, pressure, density, speed, temperature and many other units of measurement used in engineering calculations. The converter provides the ability to convert complex values of units of measurement from one system of units to another. For this option to work, a special database table has also been created and filled.

When analyzing the brand composition, you can set various conditions for selecting materials: by country, by type, by standard, by group (from one to another), by product and purpose (a word or a combination of words in the description of which these words occur). The program allows you to proceed to the program search for analogues of this material among domestic and foreign materials. You can also search for information on the properties of materials, including technological ones. The program provides screen forms with information on the physical and mechanical properties of materials (as shown in Figure 7), resistance to deformation during metal forming, as well as for selecting a physical or mechanical characteristic and for determining the estimated approximate value of this characteristic based on a given chemical composition material.

Figure 6. Main form of the program

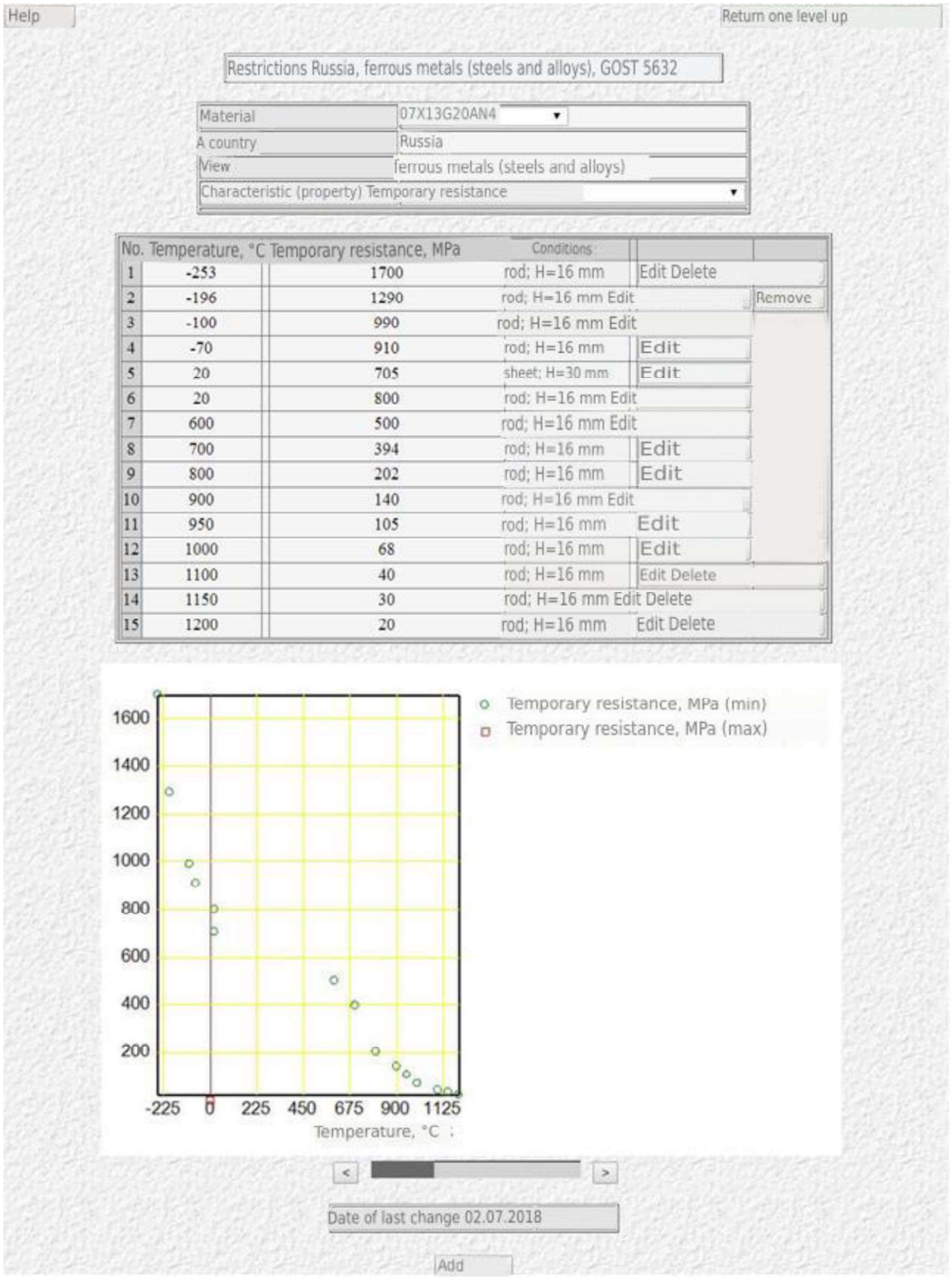


Figure 7.Mechanical properties of the materials

Analysis of the technological properties of the material offers the following information (Figure 8):

- critical temperatures: melting point; liquidus temperature; temperature A_{c1}; temperature A_{r1}; temperature A_{c3}; temperature A_{r3}; temperature A_{cm}; temperature M_n;
- technological properties: weldability; workability; tendency to temper brittleness; flocenosensitivity;
- temperature range of hot deformation: upper limit; lower limit;
- the temperature of the beginning of intensive scale formation;
- cooling conditions after hot deformation;
- operating temperatures: lower limit; very long; for a long time; limited; briefly;
- additional characteristics and features.

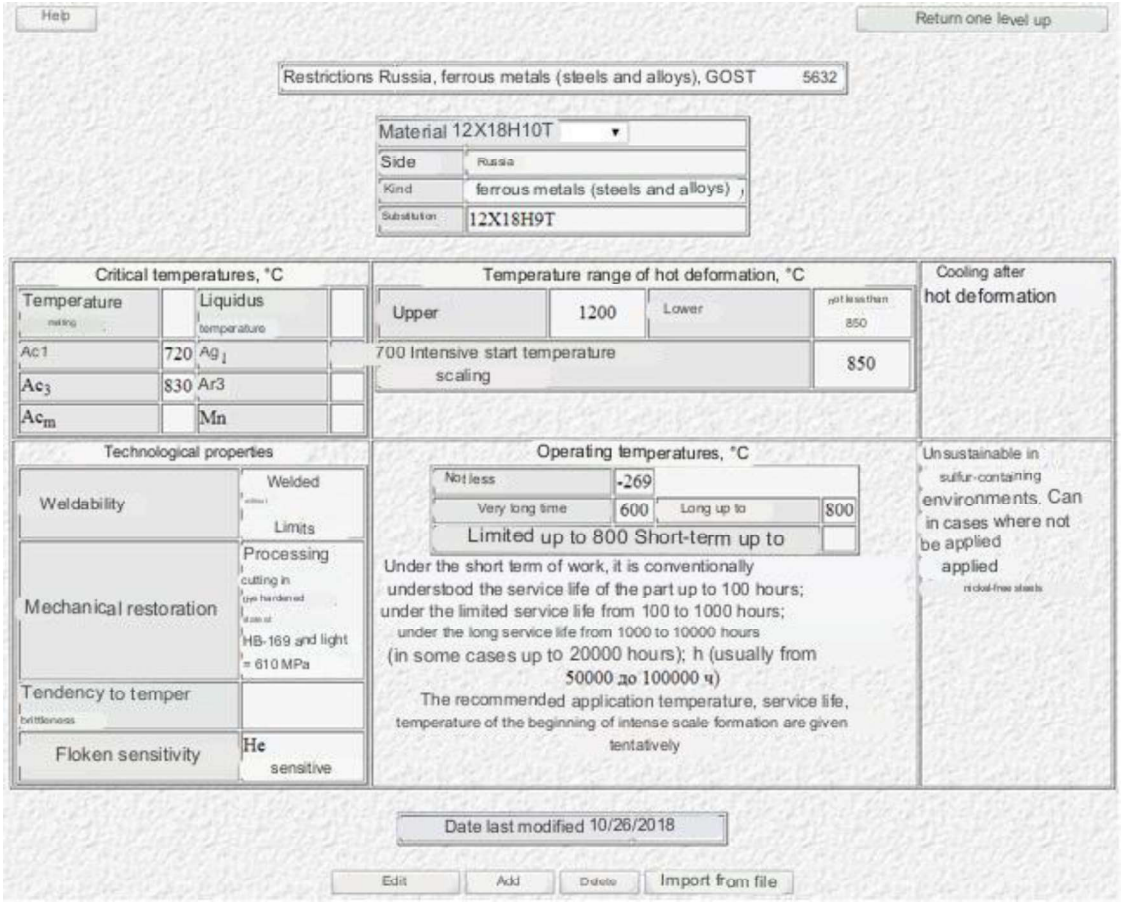


Figure 8. Technological properties of the material

The program selects the materials closest in chemical composition for which the values of this mechanical characteristic are available, builds a regression equation of its dependence on the chemical composition and calculates the approximate expected value: after selecting the material grade and characteristic, the required information is presented in the form of a table and a graphical dependence of it on the test temperature . For the main alloying elements, you can get the nature of their influence on the properties of steels and alloys (Figure 9).

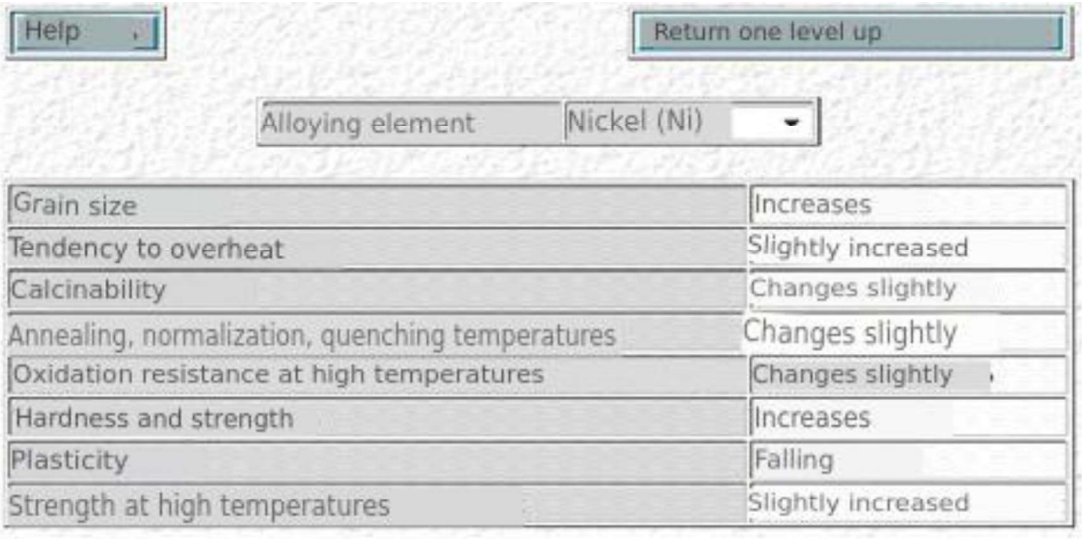


Figure 9. Influence of alloying elements and impurities on steel properties

Results of using routines for calculations. Login to the system to perform calculations is shown in Figure 10.

Figure 10. Page of programs for calculations

In this work, we used a system that includes the following main components: calculation of the deformation mode (calibration) of forming a pipe billet according to one-radius and two-radius schemes; evaluation of energy-power parameters of the process. The screen form for entering initial data has the following form (Figures 11 and 12).

The results are given in the form of two tables with deformation parameters in the molding and sizing stands. An example of a screen form for single-radius calibration is shown in Figure 13, and an example of calculating the energy-power parameters of forming a pipe billet is shown in Figure 14.

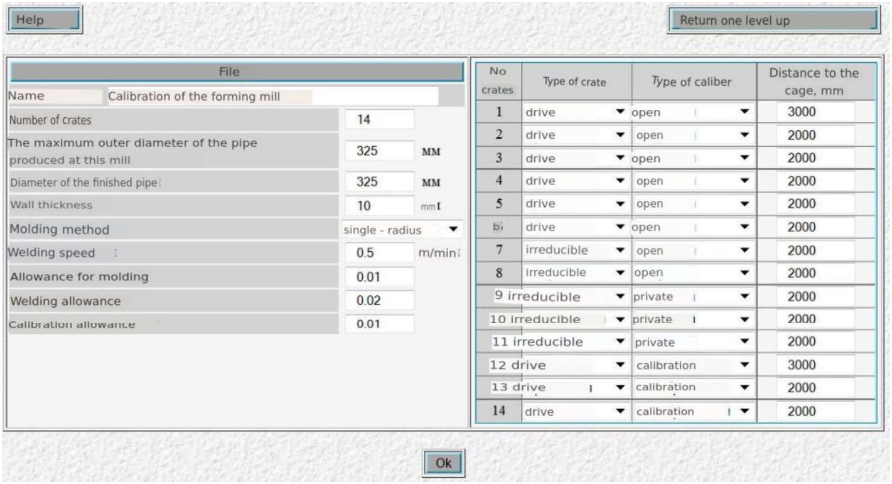


Figure 11. Screen form for entering initial data for calculating the mode of forming a tubular billet

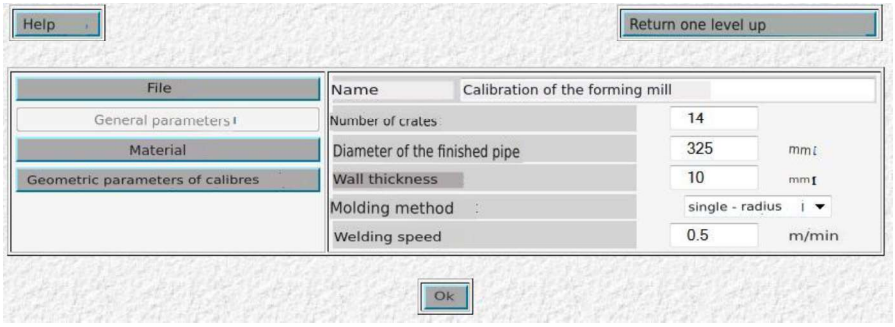
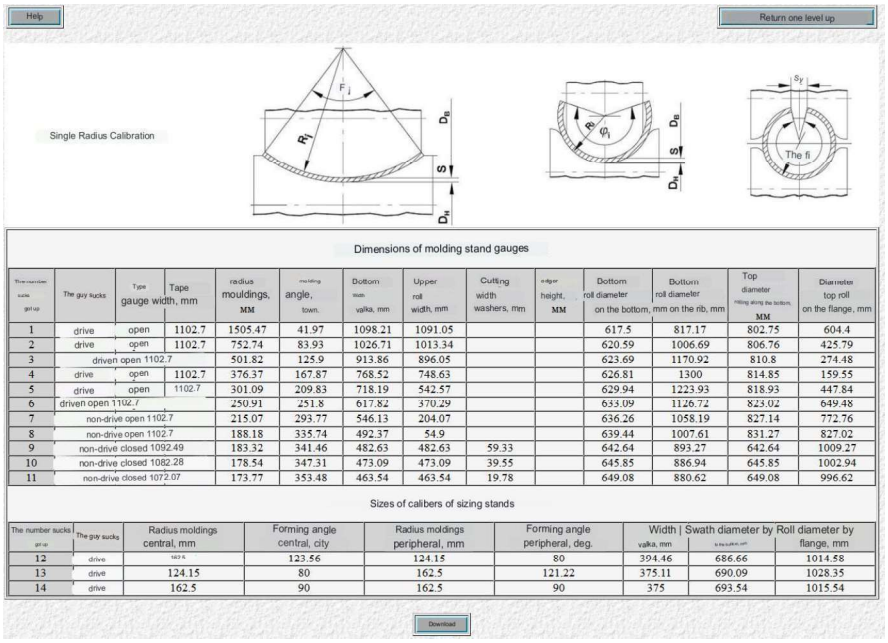


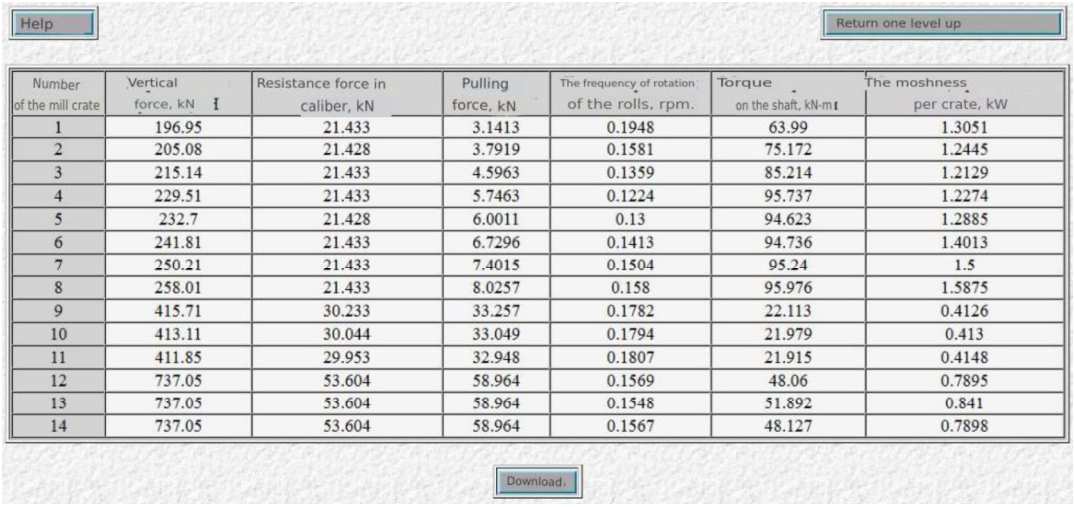
Figure 12. Screen form for entering initial data for calculating power parameters



	The guy sucks	Type	Tape gauge width, mm	radius mouldings, MM	angle, town.	Bottom valka, mm	Upper roll width, mm	Cutting width washers, mm	edger height, MM	Bottom roll diameter on the bottom, mm	Bottom roll diameter on the rib, mm	Top diameter MM	Diameter top roll on the flange, mm
1	drive	open	1102.7	1505.47	41.97	1098.21	1091.05			617.5	817.17	802.75	604.4
2	drive	open	1102.7	752.74	83.93	1026.71	1013.34			620.59	1006.69	806.76	425.79
3	driven	open	1102.7	501.82	125.9	913.86	896.05			623.69	1170.92	810.8	274.48
4	drive	open	1102.7	376.37	167.87	768.52	748.63			626.81	1300	814.85	159.55
5	drive	open	1102.7	301.09	209.83	718.19	542.57			629.94	1223.93	818.93	447.84
6	driven	open	1102.7	250.91	251.8	617.82	370.29			633.09	1126.72	823.02	649.48
7	non-drive	open	1102.7	215.07	293.77	546.13	204.07			636.26	1058.19	827.14	772.76
8	non-drive	open	1102.7	188.18	335.74	492.37	54.9			639.44	1007.61	831.27	827.02
9	non-drive	closed	1092.49	183.32	341.46	482.63	482.63	59.33		642.64	893.27	642.64	1009.27
10	non-drive	closed	1082.28	178.54	347.31	473.09	473.09	39.55		645.85	886.94	645.85	1002.94
11	non-drive	closed	1072.07	173.77	353.48	463.54	463.54	19.78		649.08	880.62	649.08	996.62

The number sucks	The guy sucks	Radius moldings central, mm	Forming angle central, city	Radius moldings peripheral, mm	Forming angle peripheral, deg.	Width | Swath diameter by Roll diameter by valka, mm	flange, mm
12	drive	162.5	123.56	124.15	80	394.46	686.66	1014.58
13	drive	124.15	80	162.5	121.22	375.11	690.09	1028.35
14	drive	162.5	90	162.5	90	375	693.54	1015.54

Figure 13. Tables with the results of calculating the mode of forming a tubular billet



Number of the mill crate	Vertical force, kN	Resistance force in caliber, kN	Pulling force, kN	The frequency of rotation of the rolls, rpm.	Torque on the shaft, kN-m	The moshness per crate, kW
1	196.95	21.433	3.1413	0.1948	63.99	1.3051
2	205.08	21.428	3.7919	0.1581	75.172	1.2445
3	215.14	21.433	4.5963	0.1359	85.214	1.2129
4	229.51	21.433	5.7463	0.1224	95.737	1.2274
5	232.7	21.428	6.0011	0.13	94.623	1.2885
6	241.81	21.433	6.7296	0.1413	94.736	1.4013
7	250.21	21.433	7.4015	0.1504	95.24	1.5
8	258.01	21.433	8.0257	0.158	95.976	1.5875
9	415.71	30.233	33.257	0.1782	22.113	0.4126
10	413.11	30.044	33.049	0.1794	21.979	0.413
11	411.85	29.953	32.948	0.1807	21.915	0.4148
12	737.05	53.604	58.964	0.1569	48.06	0.7895
13	737.05	53.604	58.964	0.1548	51.892	0.841
14	737.05	53.604	58.964	0.1567	48.127	0.7898

Figure 14. The results of the calculation of the energy-power parameters of forming a tubular billet

The developed methodology and programs of the proposed computer system were used to calculate the roll gauges and the stress-strain state of the metal, and were tested when calculating the production process of longitudinally welded pipes on the Olimpia 80 production line (Techno trade LLC, Ozerki, Kaliningrad region, Russia).

Discussion

Distance learning system. It provides a number of additional features, in particular, it is possible to estimate the time spent by students on the study of individual academic disciplines, to evaluate the assimilation of individual topics based on test results, as well as the load by semesters. Independent testing allows you to evaluate the compliance of the programs used with the requirements of the standards

Practice has shown that a liberal scheme for the presentation of educational materials, when a student is given full access to educational materials, and he himself determines the sequence and timing of the implementation of activities, weakly stimulates systematic work. Pathway learning provides stimulation for students to work during the semester, and timely apply administrative measures to manage the learning process. The presence of test protocols with student data and correct answers reduces the risk of conflict situations.

Systematic sequential testing ensures the availability of a sufficient number of grades and points for each discipline per student, allows you to increase the reliability of knowledge assessment and implement the rating calculation. The rating calculation takes into account all types of control activities (practical and seminar classes, tests, homework, essays, laboratory work, self-testing, classroom testing, attendance, rhythm) with weighting coefficients. At the same time, the number of attempts is limited, and for each subsequent attempt, the score is reduced by 5%. This encourages the student to study the material before testing, rather than trying to

achieve a result through additional attempts. The current rating can be calculated at any time, which allows you to identify lagging students at the beginning of the semester. A sufficiently large number of assessments, a shift in emphasis to intra-semester work increases the objectivity of knowledge assessment.

Along with improving the organization of the educational process, the use of a computer system clearly shows the work of teachers - the availability of educational materials, tests, the presence of grades, exactingness, activity in the system, both the teachers themselves and students in a particular academic discipline. The rather successful use of computer control of independent work of students has largely become possible due to the fact that it practically does not increase the workload of teachers, except for their direct responsibility - to prepare teaching materials and control tools, as well as to monitor the work of students. Administrative control is an important factor. The administration has up-to-date information about the availability of educational materials in the system and can check and control it, as well as the duration of students' work in each academic discipline, can easily check the compliance of educational material with tests and the course program.

Research using the database program. The use of the database program and its supporting application showed that it is a description of the data bank of ferrous and non-ferrous metals and alloys in Russia and a number of foreign countries, their technological properties, heat treatment modes, physical and mechanical characteristics at various temperatures and in real time using A flexible query system allows you to obtain the necessary information in order to make optimal decisions in the process of planning both an experiment and a real production process.

Research and analysis of the process of production of tubular blanks of a characteristic assortment (as part of student research work or graduation qualification work). The results of the calculation of the stress-strain state showed that the maximum level of longitudinal tensile strains and stresses lies in the region of the elastic state, which indicates that there is no danger of corrugation at the edges of the strip. Predicting the magnitude of residual stresses also showed that they are at a fairly low level.

Conclusion

The system allows to implement a model of blended learning (full-time and part-time), as well as individual learning along trajectories that increases motivation and stimulates independent work of students. The system has an intuitive and user-friendly interface and does not require any special knowledge from users when working with it. Due to the introduction of a point-rating system, the quality of education increases (a more serious attitude of students to study and an improvement in the level of knowledge). It is possible to receive operational integrated information about the progress of individual students, groups of students, etc., and also allows parents to control their children.

The developed database with its structure and application, as well as the data entered into it on the chemical

composition of steels and alloys, heat treatment modes, physical, mechanical and technological properties, as well as subroutines for calculating technological problems, are a significant part of the independent work of students in the process of acquiring professional engineering competencies.

Recommendations

The software package (system) of distance education created and proposed in this work can be recommended for use both for educational purposes and in scientific research in the development, improvement, management of technological processes for the production of metal products, design of machines and metal structures.

Notes

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